Membrane Emulsification for the Continuous Production of Cellulose Beads

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Cellulose Dissolution

An estimated 1.5 × 10^{12} tons of cellulose is generated every year making it the most abundant biopolymer on the planet.[1] However, the wide scale sustainable use of this almost inexhaustible raw material is hindered by its low solubility by virtue of an extensive hydrogen bonding network (*Figure 1, **A***).

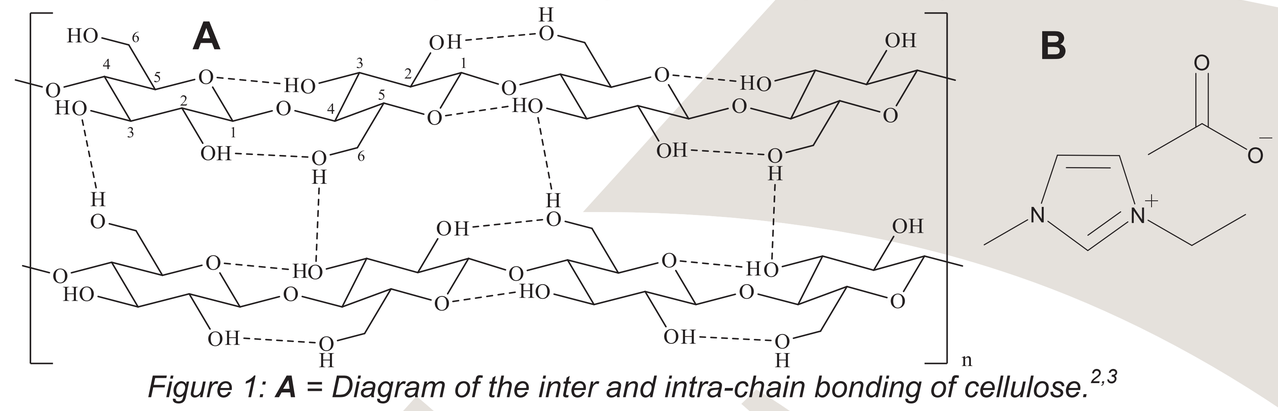


*Figure 1: **A** = Diagram of the inter and intra-chain bonding of cellulose.[2,3]*
***B** = the ionic liquid 1-ethyl-3-methylimidazolium acetate*

Ionic liquids (ILs) — molten salts with a melting point <100°C—can solvate cellulose opening up a potential processing avenue especially when used with a co-solvent such as DMSO (i.e. reduced viscosity, faster dissolution, less ionic liquid).[4, 5]

This research shows the use of such a solvent system (EMIMAc, DMSO, *Figure 1 **B**)* to process cellulose solutions via a membrane emulsification technique into sustainable and industrially important cellulose beads often used in water filtration, chromatography as well as solid supports.

Membrane Emulsification

Emulsions, a mixture of two immiscible liquids, are usually formed via high shear force processes but there is a drive towards lower energy and less harsh membrane emulsification techniques which also provide greater control over dispersity and droplet size (*Figure 2*).

Water in Oil emulsions (W/O) were used as a precursor to cellulose bead products. Specifically, solvated cellulose solutions were dispersed in a continuous sunflower oil phase then subject to an anti-solvent producing solid cellulose beads (*Figure 3*).

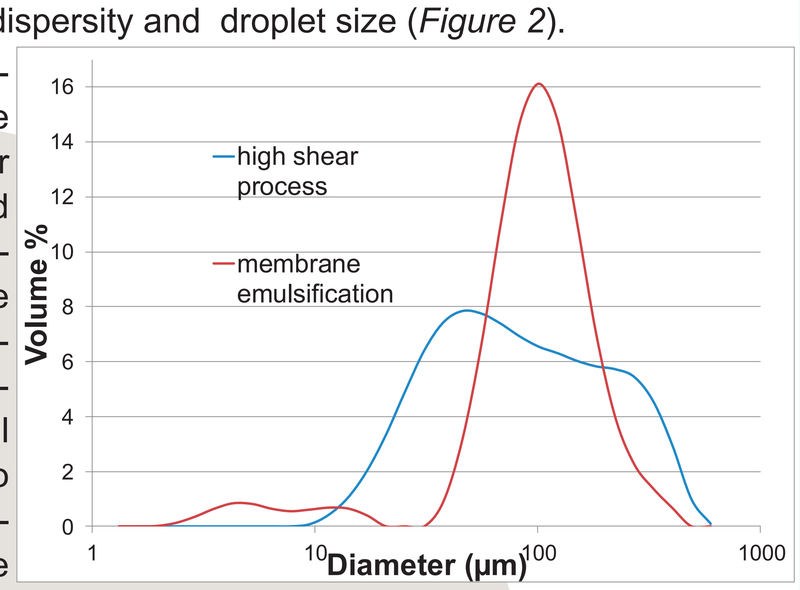
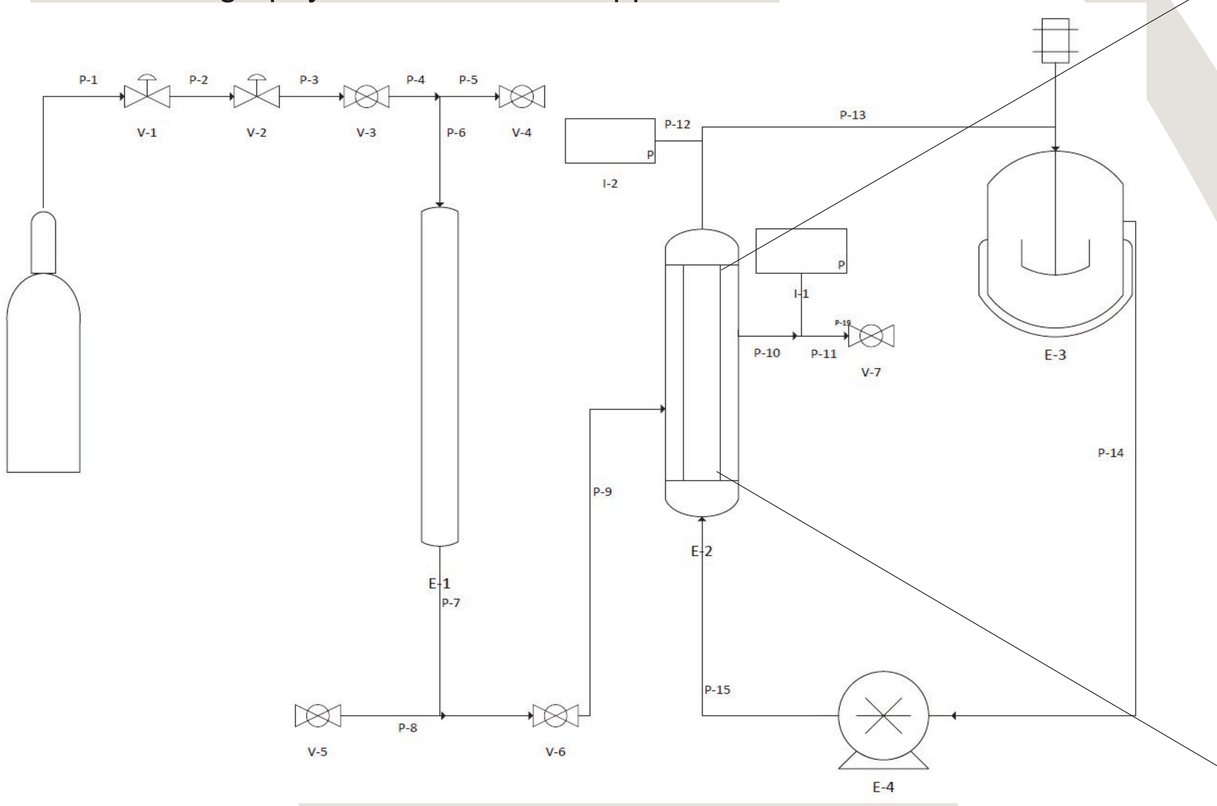


Figure 2: A comparison between the dispersity and average size of cellulose beads made via two techniques.



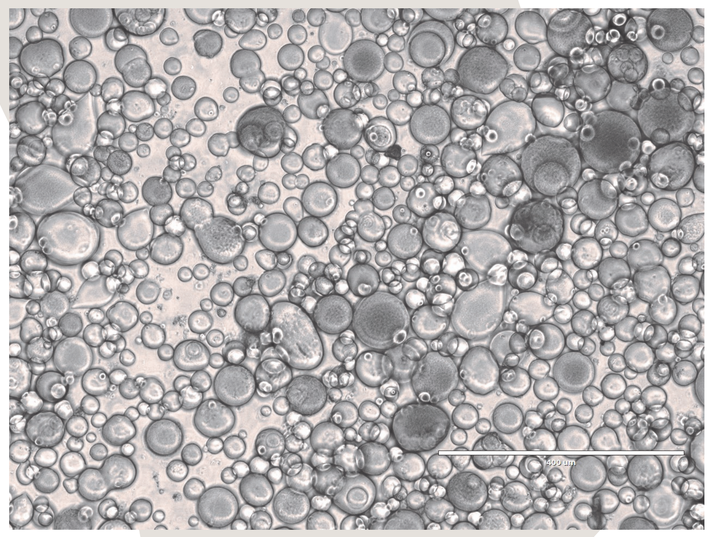
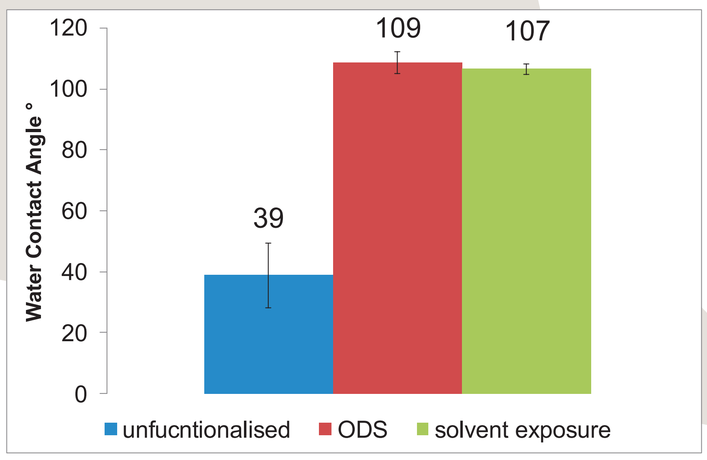


Figure 3: Optical Micrograph of cellulose beads—scale bar = 400µm

Results

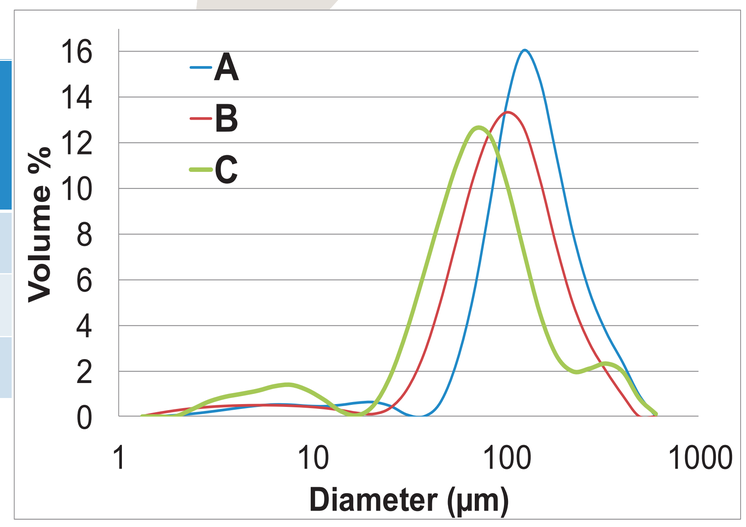
Membrane hydrophobisation

A hydrophobic membrane was required to reduce the interaction of the aqueous phase (EMIMAc, DMSO, cellulose) with the membrane. Shirasu Porous Glass (SPG) membranes were hydrophobised with 5 vol% octadecyltrichlorosilane (ODS), a functionality that was found to be stable in the solvent system (DMSO, EMIMAc—42 hrs 80°C).



Influence of Processing Conditions

	Cellulose wt%	Conti. Phase Flow Rate ($Lmin^{-1}$)	Conti. Phase Temp (°C)	Surf. Wt%
A	4	0.4	30	0.25
B	6	1.4	45	1.13
C	8	2.4	60	2.00



References

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